Regional Operational Plan SF.2A.2019.02

Operational Plan: Kachemak Bay Hardshell Clam Stock Assessment, 2018–2020

by

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and

Adam St. Saviour

January 2019

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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SIGNATURE/TITLE PAGE

Project Title:	Kachemak Bay hardshell clam stock assessment, 2018–2020
Project leader(s):	Michael Booz, Fisheries Biologist II
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Project Nomenclature:	
Period Covered	FY 19 through FY 21
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Approval

Title	Name	Signature	Date
Project leader	Michael D. Booz		
Project supervisor	Carol Kerkvliet		
Biometrician	Patricia Hansen		
Research Coordinator	Tim McKinley		

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ABSTRACT

In 2018–2020, Kachemak Bay hardshell clam abundance surveys will be conducted on beach sections in Jakolof Bay, China Poot Bay, and Chugachik Island. Each beach section will be sampled just once over the 3-year period to estimate the density, abundance, and length composition of sublegal and legal Pacific littleneck and butter clam. These data will be compared to corresponding historical data to assess the current status of the hardshell clam stock as it relates to supporting sustainable harvest opportunities.

Key words: Hardshell clams, Pacific littleneck, *Leukoma staminea*, butter clam, *Saxidomus giganteus*, Kachemak Bay, density, abundance, length

INTRODUCTION

PURPOSE

The purpose of this project is to estimate the abundance, density, and length composition of sublegal and legal sized hardshell clams on a total of 8 beach sections in Jakolof Bay, China Poot Bay, and Chugachik Island which can then be compared to corresponding historical data dating back to 1999 to assess the current status of the stock and sustainable harvest opportunities.

BACKGROUND

Kachemak Bay (Figure 1) supports hardshell clam sport, personal use, and subsistence fisheries and has historically supported commercial fisheries (Table 1). The generic term, hardshell clam, refers to the Pacific littleneck (*Leukoma staminea*) and butter clam (*Saxidomus giganteus*). Since 1997, these fisheries have been managed by the *Southern District Hardshell Clam Fishery Management Plan* (5 AAC 38.318). The plan limits the annual noncommercial (sport and personal use) and commercial harvests to 160,000 pounds and 40,000 pounds, respectively. In 2007, the Alaska Board of Fisheries (BOF) made a positive "customary and traditional use" finding for shellfish in the portion of Cook Inlet outside the Anchorage–Matanuska-Susitna–Kenai Peninsula nonsubsistence area. The amount "necessary for subsistence uses" of hardshell clams was 6,800–10,200 pounds (round weight).

The Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries (CF) and Division of Sport Fish (SF) conducted annual hardshell clam abundance surveys throughout Kachemak Bay from the mid-1990's through 2010 (Szarzi et al. *In prep*). Sampling occurred on small beach sections from Jakolof Bay to Chugachik Island (Table 2). The surveyed beach sections included Jakolof Bay, China Poot Bay, and Chugachik Island. These beach sections were selected for long-term monitoring based on the locations where noncommercial and commercial digger effort had been consistently higher. At each location, abundance was estimated from the density of clams (clams/m^2) in hand-dug quadrats. Although the primary focus of these surveys was to estimate the abundance of legal-sized Pacific littleneck (38.1 mm) and butter clam (63.5 mm), captured sublegal hardshell clams were also used to assess recruitment. The density of sublegal hardshell clams was probably underestimated in these surveys due to an inability to detect clams below a certain size.

Although the survey methods differed between areas and were also modified in recent years, sampling was eventually standardized as follows: 1) at Jakolof and China Poot bays, 0.25 m^2 quadrats were hand dug along the elevation gradient (transect) perpendicular to the water line from +5 ft elevation to the water level at a −3.0 ft tide and 2) at Chugachik Island, quadrats were randomly located on topographical maps prior to sampling and the surveys were conducted to the water level at −4.8 ft (Booz et al. *In prep*).

In Jakolof Bay from 2001 through 2005, sites were sampled throughout the bay every other year (Table 3). In 2008 and 2010, sampling in Jakolof Bay focused on fewer sites with more intensive sampling (greater number of quadrats) to detect change in abundance in each beach section. In China Poot Bay, sampling occurred primarily on the lower island in 1999–2003 and 2005. In 2009, index areas were established and sampled on both the lower and upper islands. These index areas were located where abundance was highest which helped reduce the amount of quadrats required to conduct an intensive survey of each island. Additionally, in 2009, several other small beach sections in China Poot Bay were sampled as well.

Overall, these surveys indicated a substantial decline in the density of legal-sized hardshell clams in all locations (Tables 4–6). The density of sublegal hardshell clams in these surveys suggested poor recruitment of Pacific littleneck but little change in recruitment of butter clam. The causes of these declines in abundance and recruitment are unknown.

The sport and personal use fisheries have been restricted by gear, legal sizes, and bag and possession limits. Statewide regulations restrict gear in these fisheries to rakes, shovels, manually operated clam guns or by hand. Size restrictions were established for Pacific littleneck and butter clam to allow them to reach maturity prior to being available for harvest. From 1997 through 2010, the sport and personal use fisheries were restricted to a bag limit of 1,000 Pacific littleneck and 700 butter clam. In response to the hardshell clam declines, ADF&G issued an emergency order (EO) to restrict the hardshell clam bag and possession limit to 80 clams in combination in 2011. In 2012, the BOF adopted an ADF&G proposal to restrict all noncommercial Kachemak Bay hardshell clam fisheries including the subsistence fishery to a bag and possession limit of 80 clams in combination.

Sport and personal use annual harvests of hardshell clams have been estimated since 1981 by the Statewide Harvest Survey (SWHS) (Table 1). The SWHS harvest was estimated in gallons from 1981 through 2010 and in numbers since 2011. The composition (proportions of Pacific littleneck and butter clam) of the harvest is unknown. The hardshell clam harvest in these fisheries has historically ranged from 3,562 gal in 2008 to 26,597 gal in 1988 (30,277–226,075 lb; 1 gal is approximately equal to 8.5 lb) Since 2011, the annual harvest has averaged roughly 26,000 clams with a range of roughly 5,300 clams in 2016 to nearly 35,000 clams in 2013.

The SWHS has also estimated effort for all shellfish in Lower Cook Inlet, including Kachemak Bay, ranging from 25,391 harvester-days in 1981 to 1,128 days in 2016. A general decline in sport and personal use shellfish effort since 1981 reflects the decline and eventual closure of most important shellfish stocks in Kachemak Bay: the king crab (*Paralithodes* spp.) fishery closed in 1984, the shrimp (*Pandalus* spp.) fishery closed in 1996, and the Dungeness crab (*Cancer magister*) fishery closed in 1998. The Tanner crab (*Chionoecetes* spp.) fishery closed in 2002 but reopened from 2008 to 2012 and again in 2017. From 2002 to 2007, the hardshell clam fishery was the only major shellfish fishery that remained open and effort, assumed to target hardshell clams, averaged 6,252 harvester-days.

In 2003, the most recent comprehensive subsistence survey was completed by ADF&G in Lower Cook Inlet. A total of 450 gal (1,350 lb) of hardshell clams were harvested by the residents of Nanwalek and Port Graham. Between 2008 and 2011, a total of 39 subsistence permits were issued and 3 permittees reported a total harvest of 26 gal.

Permits are no longer required because compliance was low and information can be derived from the subsistence surveys. No subsistence permits have been issued since 2015.

When the commercial fishery last opened, it was a small hand-dug fishery that primarily harvested Pacific littleneck. From 1997 to 2010, the total annual harvest averaged 15,532 lb and ranged from 1,222 lb in 2006 to over 31,000 lb in 1997. No commissioner's permits have been issued for this fishery since 2006.

OBJECTIVES

PRIMARY OBJECTIVES

1) Estimate the abundance of legal-sized (≥38.1 mm) Pacific littleneck on each beach section such that all estimates of abundance are within 35% of the true value 95% of the time.
2) Estimate the length composition (10 mm groups) of Pacific littleneck and butter clam on each beach section such that the combined estimates for each beach are within 6 percentage points of the true value 95% of the time.

SECONDARY OBJECTIVES

1) Estimate the abundance of sublegal-sized (<38.1 mm) Pacific littleneck on each beach section.
2) Estimate the abundance of lega1-sized (≥63.5 mm) and sublegal-sized (<63.5 mm) butter clam on each beach section.
3) Estimate the density of legal- and sublegal-sized littleneck and butter clam on each beach section.
4) Conduct habitat mapping at Chugachik Island beach section.

METHODS

STUDY DESIGN

Abundance

Kachemak Bay hardshell clams will be sampled once at each of 8 beach sections located in either Jackolof Bay, China Poot Bay, or Chugachik Island over a 3-year period (between 2018 and 2020) to estimate abundance and density (clams/m^2) of legal- and sublegal-sized Pacific littleneck and butter clam (Table 7, Figures 2–4). Because total area differs between beach sections, densities will be used to facilitate standardized comparisons between beaches, beach sections, and years. The beach sections representing a variety of habitat types and harvest levels and those that were also sampled more consistently in the past were chosen for this project. The total amount of each beach section sampled will range from 0.1% to 1.0% (refer to areas in Figures 2–4). The number of transects and quadrats will be same as in 2008–2010 (Table 3), except at Chugachik Island, where the number of sampled quadrats will be increased to achieve greater precision and a sampling density (quadrats per area) similar to other beach sections. Surveys will be scheduled in season on the largest predicted minus tides (at least −3.0 ft) available in July and August annually (Table 8).

As was done in the past (Booz et al. *In prep*), sampling will begin at the +1.2 m (+5.0 ft) tide level for all locations and end at the −0.9 m (−3.0 ft) tide level for Jakolof and China Poot bays and at the −1.5 m (−4.8 ft) level for Chugachik Island. At all locations, surveys will last through

the minus tide and continue until the target sample size is met or when the tide returns to the +1.2 m tide level (Figure 5). The beach will be excavated within 0.25 m^2 quadrats systematically placed along transects that run perpendicular to the water's edge. The number of transects for each section will be the same as the 2008–2010 surveys (Table 7). The distance from the start location to the first transect will be randomly selected and the remaining transects will be systematically placed across the section. The transect heading will generally be perpendicular to the top of the site but may be adjusted to avoid digging in the same area as previous studies. The number of quadrats per transect is approximately the same as the 2008–2010 surveys and is based on transect length and a minimum number of 4 quadrats per transect.

The abundance of legal- and sublegal-sized Pacific littleneck and butter clam in each section will be estimated by expanding quadrat counts (Equations 1–5, below). It is anticipated that all abundance estimates will be poststratified based on elevation. The stratification will be evaluated for each section based on the variability of the section estimates. Density in each section will also be estimated for legal- and sublegal-sized Pacific littleneck and butter clam as the estimated number of clams divided by the area of beach section.

Sample Sizes

Data collected at Jakolof and China Poot bays in 2008–2010 were used to estimate precision of the abundance and density estimates for each beach section in 2018–2020 (Table 9). Because sampling effort will be the same as previous years, it is anticipated that the precision will also remain the same.

Composition

All Pacific littleneck and butter clam that are collected will be measured and recorded by section, transect, quadrat, and dig date. Surveyors will be careful not to include "mudders," which are clam shells that appear to be living but are filled with mud. Other species of clams will be enumerated by species or as "Other" and returned to the excavated hole and reburied or collected as specified by the project leader.

Sample Sizes

All sampled hardshell clams will be measured for length. The 2008–2010 clam densities were used to calculate the expected number of hardshell clams that will be sampled in 2018–2020 using a 75% anticipated decline (based on the lack of recruitment in previous surveys; Table 7). All butter clam and Pacific littleneck will be assigned to a respective 10 mm size bin for sublegal- and legal-sized clams.

The objective criterion was determined with the methods of Thompson (1987) using the anticipated number of samples and adjusting for 10% breakage.

Habitat Mapping

Historically, the estimated total area for the Chugachik Island beach section was calculated using traditional mapping tools (Szarzi et al. *In prep*). During density sampling in 2018–2020, global positioning system (GPS) and elevation data will be collected. GPS points will be collected along the outer perimeter of the study area and along the water line at −4.8 ft. Elevation data will be collected along transects at the top of the study area, at each quadrat, and on the water line at −4.8 ft.

DATA COLLECTION

A clam fork (pronged garden rake) will be used to remove all substrate from inside the sampling quadrat to a depth of 20 to 34 cm or until Pacific littleneck and butter clam are not found (Appendix A1). All Pacific littleneck and butter clam will be collected and placed in individual bags associated with a quadrat. Other species will be enumerated in the field and replaced in the hole unless collection is necessary for identification. The dig order, mussel cover, and initial Pacific littleneck and butter clam counts will be entered on a datasheet after the quadrat has been completely dug (Appendix B1). At the end of the survey day on each beach section, the length of every Pacific littleneck and butter clam will be measured and recorded on a separate datasheet (Appendix B2). All quadrat and clam data recorded on datasheets will be entered into a database in the laboratory (Appendix C1).

The GPS coordinates collected for every dug quadrat will be proofed with a georeferenced location and with the measured quadrat distances along each transect. The GPS coordinates will also be collected at the top and bottom of each transect and the boundary of each section.

At Chugachik Island, the surveyed area of clam habitat will be determined from coordinates collected by GPS and field measurements and assessment in ArcGIS. The length of each transect and the number of transects will provide the measurements required to calculate area of clam habitat. Quadrat elevation will be determined by using a surveyor's level and an elevation rod to measure the height above the water level at a known time or by recording the time the rising water flooded the quadrat location (Appendix B3). Elevations will also be collected at the top and bottom of every transect and along the site boundaries as time allows. All elevation data will be used to refine the elevation rasters in each section to 1 ft elevation increments in ArcGIS. No elevation data will be collected at Jakolof and China Poot bays because elevation rasters are complete. All quadrats dug in Jakolof and China Poot bays will be assigned an elevation based on its geolocation in ArcGIS.

DATA REDUCTION

Data collected in the field (from each section) will be recorded on field survey forms (Appendices A1–A3) and entered into the Sport Fish Database Management System (SFDBMS; http://www.sf.adfg.state.ak.us/SF_SW_DBMS/WebSite/Default.aspx) (Appendix C1). Field survey forms will be inspected for completeness and legibility after the completion of each sampling trip.

All collected GPS data will be stored in a datalogger and immediately downloaded to a desktop computer upon returning from the field. Raw data will be imported into ArcGIS to create a shapefile of dug quadrats. All quadrat data (i.e., number of legal and sublegal clams, elevation, substrate composition, and mussel cover) will be entered into the attribute table and stored within a hardshell clam ArcGIS project. GPS data for beach sections will be used to refine study area and the elevation rasters in ArcGIS.

Data entered into the SFDBMS will be compared to those on the survey form to edit any errors and error checking protocols will be activated to detect outlying data values.

Length data will be entered electronically or manually into the SFDBMS. The project biologist will examine the database for completeness. Completed, corrected field sampling forms will be stored in a file in the project leader's office.

Following final approval of written reports, the data files, data maps, and SAS programs used to compile and analyze data will be archived on the Division of Sport Fish Intranet Docushare collection at *http://docushare.sf.adfg.state.ak.us*.

DATA ANALYSIS

Abundance

The abundance of legal- and sublegal-sized Pacific littleneck and butter clam will be estimated for each section. The abundance estimates will probably be poststratified based on elevation.

For both legal- and sublegal-sized clams of each species and beach section, the abundance of clams ($\hat{N}_s$) will be estimated as follows:

$$\hat{N}_s = \sum_{e=1}^{E_s} \hat{N}_{se} \tag{1}$$

where

s = beach section,

e = elevation stratum,

E_s = the total number of elevation strata in section s, and

$\hat{N}_{se}$ = the estimatated abundance in section s, elevation stratum e,

which is

$$\hat{N}_{se} = Q_{se} \frac{\sum_{q=1} y_{seq}}{q_{se}} \tag{2}$$

where

y_{seq} = the number of clams counted in section s, elevation stratum e, quadrat q,

q_{se} = the number of quadrats sampled in section s, elevation stratum e, and

Q_{se} = the total possible number of quadrats in section s, elevation stratum e.

The variance of the estimated abundance will be calculated as follows:

$$V\left(\hat{N}_s\right) = \sum_{e=1}^{E_s} V\left(\hat{N}_{se}\right) \tag{3}$$

where

$$V\left(\hat{N}_{se}\right) = Q_{se}\left(Q_{se} - q_{se}\right)\frac{s_{se}^2}{q_{se}} \tag{4}$$

where

s_{se}^2 = the variation between quadrats in section s, elevation strata e,

which is

$$s_{se}^2 = \frac{\sum_{q=1}\left(y_{seq} - \bar{y}_{se}\right)^2}{q_{se} - 1}. \quad (5)$$

The estimate of sublegal clams will be considered a minimum estimate because small clams may be missed by samplers.

Composition

For each section of beach, the proportion of clams in each length category, by species, will be estimated as a binomial proportion (Cochran 1977):

$$\hat{p}_{sk} = \frac{n_{sk}}{n_s} \quad (6)$$

with variance

$$\hat{V}(\hat{p}_{sk}) = \frac{\hat{p}_{sk}(1 - \hat{p}_{sk})}{n_s - 1}, \quad (7)$$

where

$\hat{p}_{sk}$ = the proportion of clams in section *s* in length class *k*,

n_{sk} = the number of clams sampled from section *s* belonging to length class *k*, and

n_s = the number of clams sampled from section *s* for length.

The section estimates will be combined to get a weight proportion of length composition as:

$$\hat{p}_k = \sum_{s=1}^{S} \frac{\hat{N}_s}{\hat{N}_\bullet} \hat{p}_{sk} \quad (8)$$

with variance

$$\hat{V}[\hat{p}_k] \approx \frac{1}{\hat{N}_\bullet^2}\left(\sum_{s=1}^{S} \hat{N}_s^2 \hat{V}[\hat{p}_{sk}] + (\hat{p}_{sk} - \hat{p}_k)^2 \hat{V}[\hat{N}_s]\right) \quad (9)$$

where:

$\hat{N}_s$ = the estimated abundance for section *s*, and

$\hat{N}_\bullet$ = sum of the section abundance estimates.

Density

For each beach section, the density D_s of legal- and sublegal-sized Pacific littleneck and butter clam will be estimated as follows:

$$D_s = \frac{N_s}{A_s} \quad (10)$$

$$V\left[\hat{D}_s\right] = \frac{V\left[\hat{N}_s\right]}{A^2} \quad (11)$$

where

A = the area (m^2) of section s.

SCHEDULE AND DELIVERABLES

A schedule for conducting field sampling will be established each year inseason and in enough time to coordinate activities with volunteers with the ADF&G Division of Commercial Fisheries, Kachemak Bay Research Reserve, Alaska Pacific University, and NOAA Kasitsna Bay Laboratory. The number of tides available in July through August will differ between the years but there are enough to complete surveys in all 8 beach sections (Table 8). Data entry of quadrat information including clams and length measurements will be completed by September 30 each year. Density, abundance, and length composition information for collection years 2018–2020 will be summarized and published in a Fisheries Data Series Report in the spring of 2021.

RESPONSIBILITIES

Michael Booz, Fishery Biologist II, Project Leader
Duties: Prepares operational plan, supervises and trains field crew with sampling and data collection, assists with field sampling, conducts data analyses, oversees ArcGIS hardshell clam project and coauthors the report.

Adam St. Saviour, Fishery Biologist III
Duties: Assists with preparing operational plan and with field sampling, conducts data analyses, and coauthors the report.

Pat Hansen, Biometrician
Duties: Technically reviews study design, sampling methods, and data analysis of operational plan, and reviews report. Provides assistance in drafting operational plan and technical assistance inseason should changes in the design be necessary.

Holly Smith, Fisheries Biologist I, Project Assistant
Duties: Assists with project planning and execution including coordinating field sampling with technicians and volunteers. Leads field crew in sampling and proofs data. May assist with coauthoring report.

Tim Blackmon, Fisheries Technician III, Crew Leader
Duties: Participates in the collection and entry of field data as outlined in the operational plan, oversees the gathering of field sampling equipment, and maintains and repairs sampling equipment. Responsible for entering data and maintaining SFDBMS database. Responsible for collecting GPS data and mapping within ArcGIS hardshell clam project.

Carol Kerkvliet, Fisheries Biologist III
Duties: Assists with collection of field data as outlined in operational plan and manages the budget.

Other assisting staff
Duties: Participates in the collection of field data as outlined in the operational plan.

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TABLES

Table 1.–Combined sport and personal use and commercial harvests in of hardshell clams in Kachemak Bay, 1981–2017.

	Sport and personal use harvest			Commercial harvest (pounds)				
	Hardshell clams							
Year	Gallons	Pounds	Number	Number of permits	Number of landings	Pacific littleneck	Butter clam	Total
1981	8,132	69,122		0	0	0	0	0
1982	5,135	43,648		0	0	0	0	0
1983	16,110	136,935		0	0	0	0	0
1984	8,891	75,574		0	0	0	0	0
1985	10,334	87,839		0	0	0	0	0
1986	20,212	171,802		5	18	17,303	0	17,303
1987	23,577	200,405		8	69	12,214	206	12,420
1988	26,597	226,075		2	32	14,449	0	14,449
1989	18,195	154,658		9	41	2,584[a]	13,675[b]	16,259
1990	11,821	100,479		19	62	36,794	0	36,794
1991	10,476	89,046		19	78	47,486	85	47,571
1992	9,993	84,941		21	117	54,631	0	54,631
1993	8,350	70,975		33	159	63,676	0	63,676
1994	13,279	112,872		32	104	44,291	0	44,291
1995	20,311	172,644		21	93	66,723	4,267	70,990
1996	29,163	247,886		25	102	53,524	233	53,757
1997	9,426	80,121		15	67	31,525	0	31,525
1998	12,431	105,664		12	40	23,465	0	23,465
1999	7,971	67,754		12	24	18,520	0	18,520
2000	14,697	124,925		11	63	20,798	0	20,798
2001	13,141	111,699		8	45	20,575	0	20,575
2002	12,047	102,400		9	33	14,310	0	14,310
2003	10,074	85,629		5	55	17,956	0	17,956
2004	8,399	71,392		8	49	11,557[c]	confidential	11,557
2005	11,571	98,354		10	34	8,525	0	8,525
2006	4,210	35,785		3	6	1,222[c]	confidential	1,222
2007	4,144	35,224		0	0	0	0	0
2008	3,562	30,277		4	7	2,400	0	2,400
2009	3,132	26,622		0	0	0	0	0
2010	2,846	24,191		0	0	0	0	0
2011			22,360	0	0	0	0	0
2012			23,406	0	0	0	0	0
2013			34,926	0	0	0	0	0
2014			19,612	0	0	0	0	0
2015			30,376	0	0	0	0	0
2016			5,318	0	0	0	0	0
2017			2,508	0	0	0	0	0

-continued-

Table 1.–Page 2 of 2.

	Sport and personal use harvest			Commercial harvest (pounds)				
	Hardshell clams			Number of	Number of	Pacific		
Year	Gallons	Pounds	Number	permits	landings	littleneck	Butter clam	Total
Averages								
1981–1996	15,036	127,806		12	55	25,855	1,154	27,009
1997–2005	11,084	94,215		10	46	18,581	0	18,581
2006–2010	3,579	30,420		1	3	724	0	724
2011–2017			22,666	0	0	0	0	0

Source: Combined sport and personal use harvests were estimated from the Statewide Harvest Survey (Mills 1982-1994; Howe et al. 1995, 1996; Alaska Sport Fishing Survey database [Internet]. 1996–present. http://www.adfg.alaska.gov/sf/sportfishingsurvey/. Anchorage, AK: ADF&G, SF. Commercial harvest information from CF fish ticket data.

Note: Some harvest data are confidential due to the limited number (<3) of participants in the fishery; this is based on Alaska statute 16.05.815.

[a] Includes 1,981 pounds sold as otter food as a result of the Exxon Valdez oil spill.

[b] Includes 1,981 pounds sold as otter food as a result of the Exxon Valdez oil spill.

[c] Includes both Pacific littleneck and confidential butter clam harvest totals.

Table 2.–Kachemak Bay hardshell clam abundance sampling location descriptions, 1999–2006.

Location	Length (m)	Area (m^2)	Total number of beach sections possible
China Poot Lower Island	340	9,907	2
China Poot Upper Island	1,600	138,616	8
China Poot West Shore	115	6,312	1
Halibut Cove Deep Island (one side)	204	2,914	2
Halibut Cove Lagoon Lower Island	492	19,810	2
Halibut Cove Lagoon West Shore	400	2,947	2
Jakolof Bay	6,800	160,263	34
Grewingk River to Mallard Bay	2,400	370,192	10
East Sadie Cove	9,800	117,600	49
West Sadie Cove	8,600	129,000	43
Chugachik Island	na	61,254	1

Table 3.–Kachemak Bay hardshell clam abundance sampling by subarea, 1999–2010.

	Jakolof Bay			China Poot Bay			Chugachik Island		
Year	Sections	Transects	Quadrats	Sections	Transects	Quadrats	Sections	Transects	Quadrats
1999				2	12	94	1	NA	45
2000				3	31	93	1	NA	44
2001	12	48	241	1	8	19	1	NA	50
2002				2	42	233	1	NA	51
2003	17	68	352	1	10	62	1	NA	51
2004							1	NA	48
2005	21	84	377	2	64	297	1	NA	56
2006							1	NA	47
2007									
2008	5	79	542				1	NA	61
2009				4	41	1787			
2010	5	74	555						

Table 4.–Pacific littleneck and butter clam density per square meter and percentage of sublegal clams at Jakolof Bay survey locations, 1999–2010.

	Pacific littleneck density			Butter clam density		
Year	Sublegal	Legal	% Sublegal	Sublegal	Legal	% Sublegal
1999	–	–	–	–	–	–
2000	–	–	–	–	–	–
2001	7.5	20.6	27	1.1	3.0	27
2002	–	–	–	–	–	–
2003	9.5	17.3	35	1.3	1.7	43
2004	–	–	–	–	–	–
2005	1.6	7.1	19	0.7	0.8	48
2006	–	–	–	–	–	–
2007	–	–	–	–	–	–
2008	1.0	4.8	18	0.9	1.1	44
2009	–	–	–	–	–	–
2010	0.6	3.4	15	1.3	1.1	55

Table 5.–Pacific littleneck and butter clam density per square meter and percentage of sublegal clams at China Poot Bay lower island survey locations, 1999–2010.

	Pacific littleneck density			Butter clam density		
Year	Sublegal	Legal	% Sublegal	Sublegal	Legal	% Sublegal
1999	60.6	41.9	59	27.2	40.9	40
2000	85.1	44.2	66	19.0	44.2	30
2001	32.6	21.1	61	28.8	43.8	40
2002	56.7	28.9	66	26.8	42.3	39
2003	8.2	5.2	61	31.1	43.2	42
2004	–	–	–	–	–	–
2005	2.5	3.1	45	24.9	36.0	41
2006	–	–	–	–	–	–
2007	–	–	–	–	–	–
2008	–	–	–	–	–	–
2009	2.2	2.9	43	19.2	19.9	49
2010	–	–	–	–	–	–

Table 6.–Pacific littleneck and butter clam density per square meter and percentage of sublegal clams at Chugachik Island survey locations, 1999–2010.

	Pacific littleneck density			Butter clam density		
Year	Sublegal	Legal	% Sublegal	Sublegal	Legal	% Sublegal
1999	8.8	42.0	16	4.3	5.7	43
2000	12.9	44.5	22	2.4	3.2	43
2001	12.6	49.6	20	3.4	2.8	55
2002	13.4	30.9	31	2.4	2.0	55
2003	14.3	31.1	32	3.5	3.7	49
2004	5.9	19.8	23	4.8	2.3	68
2005	5.1	12.1	29	6.8	2.1	76
2006	3.5	10.9	24	5.7	4.0	59
2007	–	–	–	–	–	–
2008	4.7	13.6	25	6.4	3.3	66
2009	–	–	–	–	–	–
2010	–	–	–	–	–	–

Table 7.–Kachemak Bay hardshell clam abundance survey anticipated sampling effort, locations, and expected clam sample sizes, 2018–2020.

			Anticipated sampling			Sampling locations (m)				Expected number of samples			
										Pacific littleneck		Butter clam	
Study area	Section	Area (m²)	Number of transects	Number of quadrats	Percentage of total section sampled	Random transect start	Systematic transect distance	Random quadrat start	Systematic quadrat distance	Sublegal	Legal	Sublegal	Legal
Jakolof Bay													
	2	1,957	12	79	1.0	2	16	0.5	2	10	59	20	20
	3	7,568	11	111	0.4	14	16	1.4	4	14	83	28	28
	4	36,897	21	190	0.1	3	20	7.5	10	24	143	48	48
	5	2,809	14	72	0.6	5	20	0.8	1.5	9	54	18	18
	Total	49,231	58	452	0.9					57	339	113	113
China Poot Bay													
	1	4,241	8	100	0.6	7	14	2.5	3	50	75	250	375
	2	52,268	14	130	0.1	22	40	6.3	10	65	98	244	325
	5	8,597	8	40	0.1	15	22	3.7	10	10	30	50	100
	Total	65,106	30	270	0.4					125	203	544	800
Chugachik Island													
	1	61,254	12	150	0.1	17	42	4.2	10	75	188	188	113

Table 8.–Potential survey dates and tide heights available for sampling in 2018–2020.

2018			2019			2020		
Date	Time (AM)	Tide height	Date	Time (AM)	Tide height	Date	Time (AM)	Tide height
12 Jul	8:37	−4.4	16 Jun	8:41	−3.3	22 Jun	10:07	−3.0
13 Jul	9:24	−5.5	17 Jun	9:21	−3.5	23 Jun	10:46	−3.1
14 Jul	10:10	−5.8	18 Jun	10:00	−3.3	3 Jul	7:56	−3.1
15 Jul	10:56	−5.4	2 Jul	9:00	−3.6	4 Jul	8:43	−3.9
16 Jul	11:43	−4.3	3 Jul	9:43	−4.5	5 Jul	9:27	−4.1
10 Aug	8:23	−3.9	4 Jul	10:27	−4.9	6 Jul	10:09	−3.9
11 Aug	9:09	−4.9	5 Jul	11:12	−4.6	7 Jul	10:49	−3.2
12 Aug	9:53	−5.2	6 Jul	11:58	−3.8	21 Jul	9:50	−3.5
13 Aug	10:36	−4.7	31 Jul	8:43	−3.6	22 Jul	10:30	−3.8
14 Aug	11:19	−3.5	1 Aug	9:26	−4.7	23 Jul	11:10	−3.5
8 Sep	8:06	−3.0	2 Aug	10:10	−5.1	19 Aug	9:29	−3.5
9 Sep	8:50	−3.8	3 Aug	10:53	−4.8	20 Aug	10:08	−3.9
10 Sep	9:31	−3.9	4 Aug	11:38	−3.7	21 Aug	10:48	−3.5
11 Sep	10:12	−3.2	29 Aug	8:23	−3.2			
			30 Aug	9:07	−4.3			
			31 Aug	9:49	−4.5			

Table 9.–Pacific littleneck and butter clam abundance estimates and precision in Jakolof and China Poot bays, 2008–2010.

	2008						2009 and 2010					
	Pacific littleneck			Butter clam			Pacific littleneck			Butter clam		
Beach section	Abundance	SE	Relative precision	Abundance	SE	Relative precision	Abundance	SE	Relative precision	Abundance	SE	Relative precision
Jakolof Bay												
2	9,415	1,118	23	2,864	1,054	72	5,162	837	32	3,884	838	42
3	44,172	4,419	20	19,307	3,767	38	20,099	2,833	28	8,546	2,111	48
4	137,647	12,819	18	22,426	5,771	50	109,228	10,477	19	28,799	5,578	38
5	18,259	2,506	27	3,316	989	58	10,396	1,463	28	2,497	593	47
China Poot Bay												
1	No survey						10,831	2,129	39	153,009	14,672	19
2	No survey						31,154	7,646	48	677,226	80,612	23
5	No survey						39,161	7,497	38	27,366	4,977	36

FIGURES

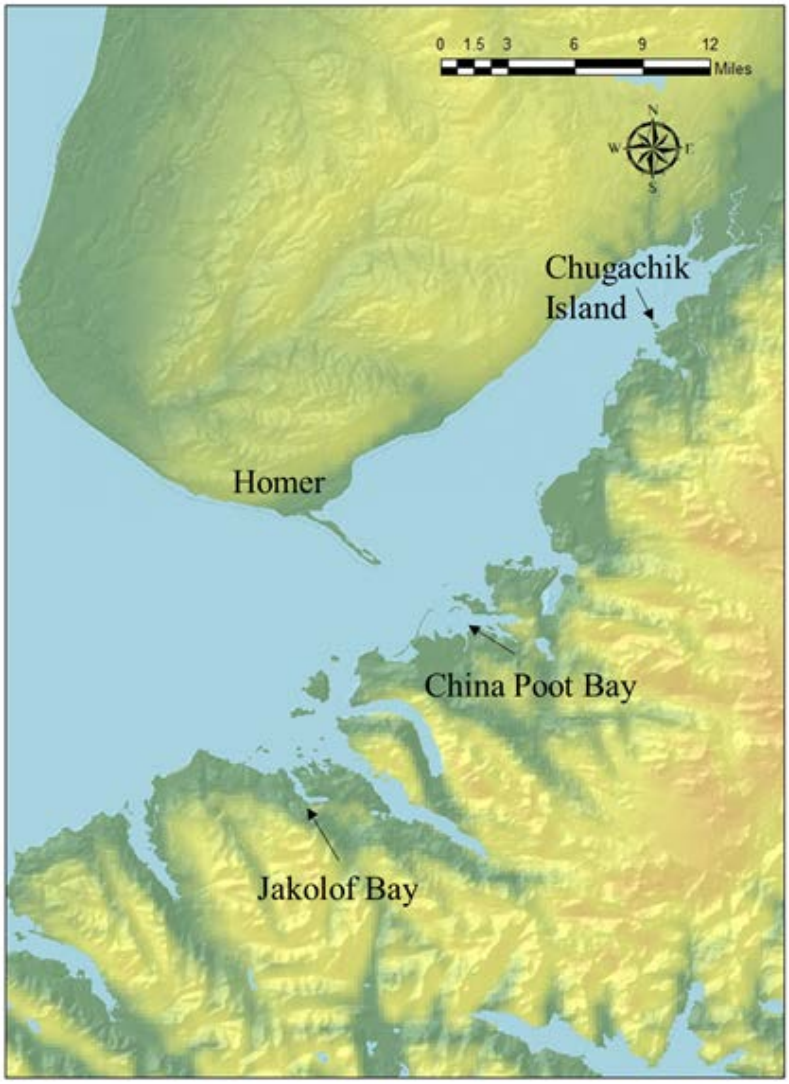


Figure 1.–Map of Kachemak Bay including hardshell clam abundance survey locations.

Figure 2.–Jackolof Bay hardshell clam abundance survey beach sections.

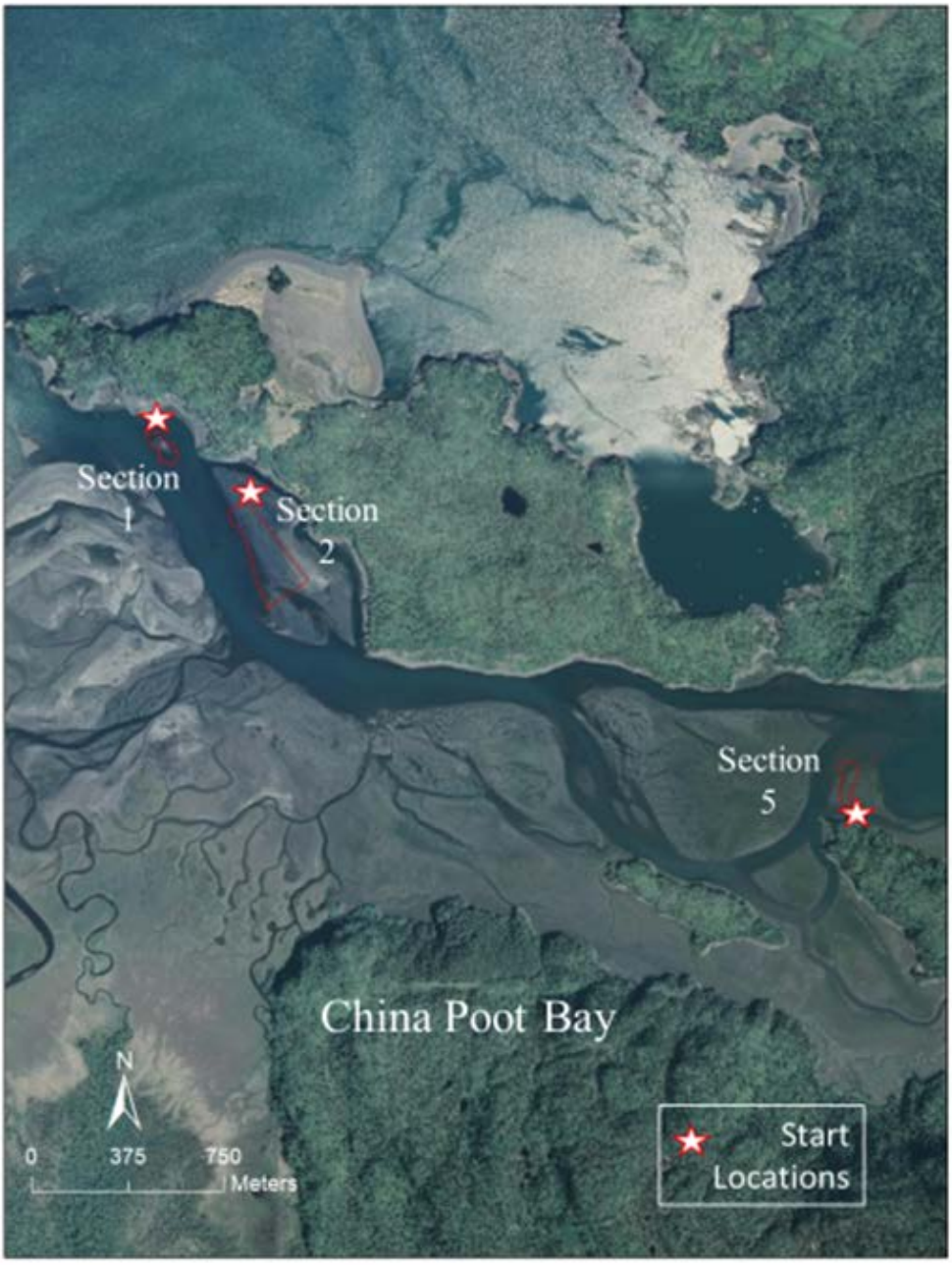


Figure 3.–China Poot Bay hardshell clam abundance survey beach sections.

Figure 4.–Chugachik Island hardshell clam abundance survey beach section.

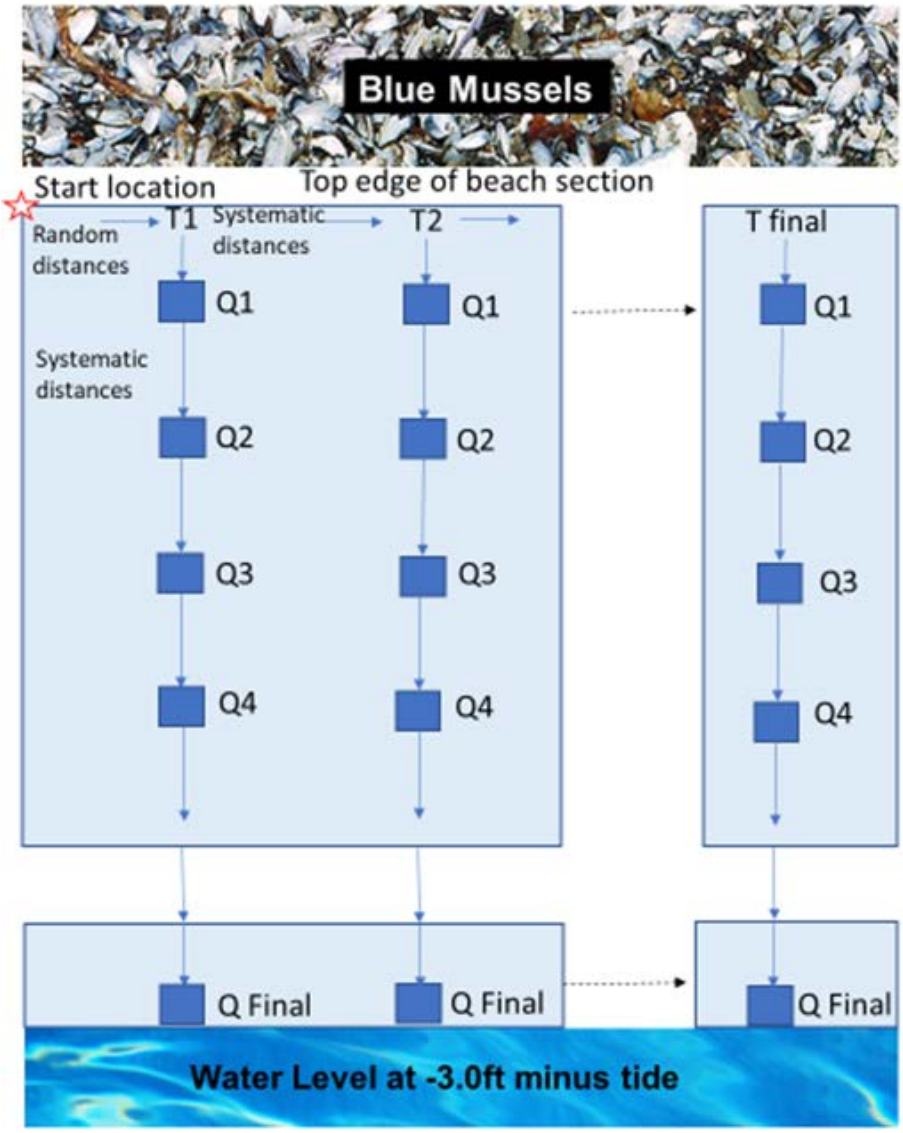


Figure 5.–Diagram of the hardshell clam abundance sampling design.

APPENDIX A: FIELD SAMPLING PROCEDURES

Surveys will be conducted on minus tides forecast to at least −1.0 m (−3.0 ft). Sampling will begin at the +1.2 m (+5.0 ft) tide level and will last through the minus tide and continue until the target number of quadrats are dug or when the tide returns to the +1.2 m tide level. Field sampling includes these steps: locating transects and quadrats, substrate classification, digging quadrats, measuring clams, and estimating quadrat elevation. Back at the office, field data sheets will be checked for accuracy and field data, along with clam measurements, will be entered into the database.

Locating Transects

Upon arrival at each section and when the tide is predicted to be at the +1.2 m tide level, the crew will first determine the start of each section by using the maps, GPS coordinates, and measured distances to nearby benchmarks using a laser rangefinder. From the section start, 2 crew members will use a tape measure to locate the random distance to the top of the first transect along the +1.2 m tide level. The rest of the transects will be located by measuring a systematic distance between each. From the last transect, the crew will measure the distance to the end of the section. This process must be done in a timely fashion due to the short length of the tide window. A labeled flag will be placed at the section start and end and the top and bottom of each transect. The bottom flag is placed when the tide is predicted to be at the −1.0 m (−3.0 ft) tide level. The crew will also use a GPS with loaded ArcGIS shapefiles to ensure that the transects are located within the predetermined section area.

Locating Quadrats

As the transects are located, the remaining crew will start to locate the quadrats along the transects. Each crewmember will be assigned specific transects. From the top of the transects, the quadrats will be located along the assigned heading using a magnetic north compass, and the distance from the top edge of the beach section to the first transect and the distance between transects will be measured with a tape measure. Both the distance from the top and the quadrat spacing will be listed on each transect datasheet. Crewmembers will continue to locate transects as the tide recedes. A flag labeled with an arbitrary code and (or) the transect and quadrat numbers will be placed at each quadrat location. The flag will remain in place until the quadrat is dug and the flagged site is surveyed.

Prior to digging the quadrat, the presence of mussels on the surface will be marked as a “yes” (Y) or “no” (N) on the transect and quadrat sampling datasheet (Appendix B1).

Quadrat Digging

A clam fork (4-prong garden rake) will be used to remove all substrate from inside the quadrat to a depth of 20 to 34 cm or until Pacific littleneck and butter clam are not found. As the substrate is removed, all Pacific littleneck and butter clam will be counted and measured. The total counts of butter clam and Pacific littleneck will be recorded on the transect and quadrat sampling datasheet (Appendix D1) in the correct row for that quadrat. Other clams will be enumerated to species or just recorded as “Other.” The substrate will be raked back into the hole while examining it for any clams missed in the initial excavation. Clams that are not retained will be replaced, siphon side up or on their side, back in the hole as it is filled in. A label will be placed inside each bag of clams collected from a quadrat with the date, section, transect, quadrat

number, and label number. The label number will be the first and last initial of the crewmember and a sequential number of the quadrat in the order it was dug (e.g., MB1, MB2,….,MB10).

Quadrat Elevation

At Chugachik Island, quadrat elevation is determined by using a surveyor's level and an elevation rod to measure the height above the water level at low tide. The estimated water level at low tide is determined from the computer software program Tides and Currents.

At slack low tide, the elevation of the low tide, quadrats, and tops and bottoms of the transects will be measured through a survey level to a survey rod to the hundredth of a foot. The rod holder will rock the rod forward and back, towards and away from the surveyor. The measurement will be at the intersection of the middle cross hair on the survey level with the height increment on the survey rod. Elevations will be recorded on the datasheet as they appear through the scope. The actual elevation will be calculated back in the laboratory by subtracting the actual elevation of the low tide.

APPENDIX B: FIELD DATA ENTRY FORMS

Appendix B1.–Transect and quadrat sampling datasheet.

Survey Location: _____ Date: _____ Page_____ of_____

Digger: Section: Transect: Transect spacing_____ Quad spacing_____

			Clam counts							
			Littleneck			Butter				
Quad #	Dig order	Mussel Cover?	sublegal final	legal Final	Total Intial/Final	sublegal final	legal Final	Total Intial/Final	Other Clams	Comments

Appendix B2.–Pacific littleneck and butter clam length datasheet.

Survey Location: ______________________ Date: __________ Page_____of______

Digger: Section: Transect:

Quad	Speices	Length	Quad	Speices	Length	Quad	Speices	Length

Appendix B3.–Elevation survey datasheet.

ADF&G Clam Site Map

Location: ___________ **Date:** **Page** ______ **of** ______

Section #: ___________

Transect______ → **water**

quad no.	***(TOP) +5.0ft***										
Distance											
Elevation/ Flood out time	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*

Transect______ → **water**

quad no.	***(TOP) +5.0ft***										
Distance											
Elevation/ Flood out time	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*

Transect______ → **water**

quad no.	***(TOP) +5.0ft***										
Distance											
Elevation/ Flood out time	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*

Transect______ → **water**

quad no.	***(TOP) +5.0ft***										
Distance											
Elevation/ Flood out time	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*

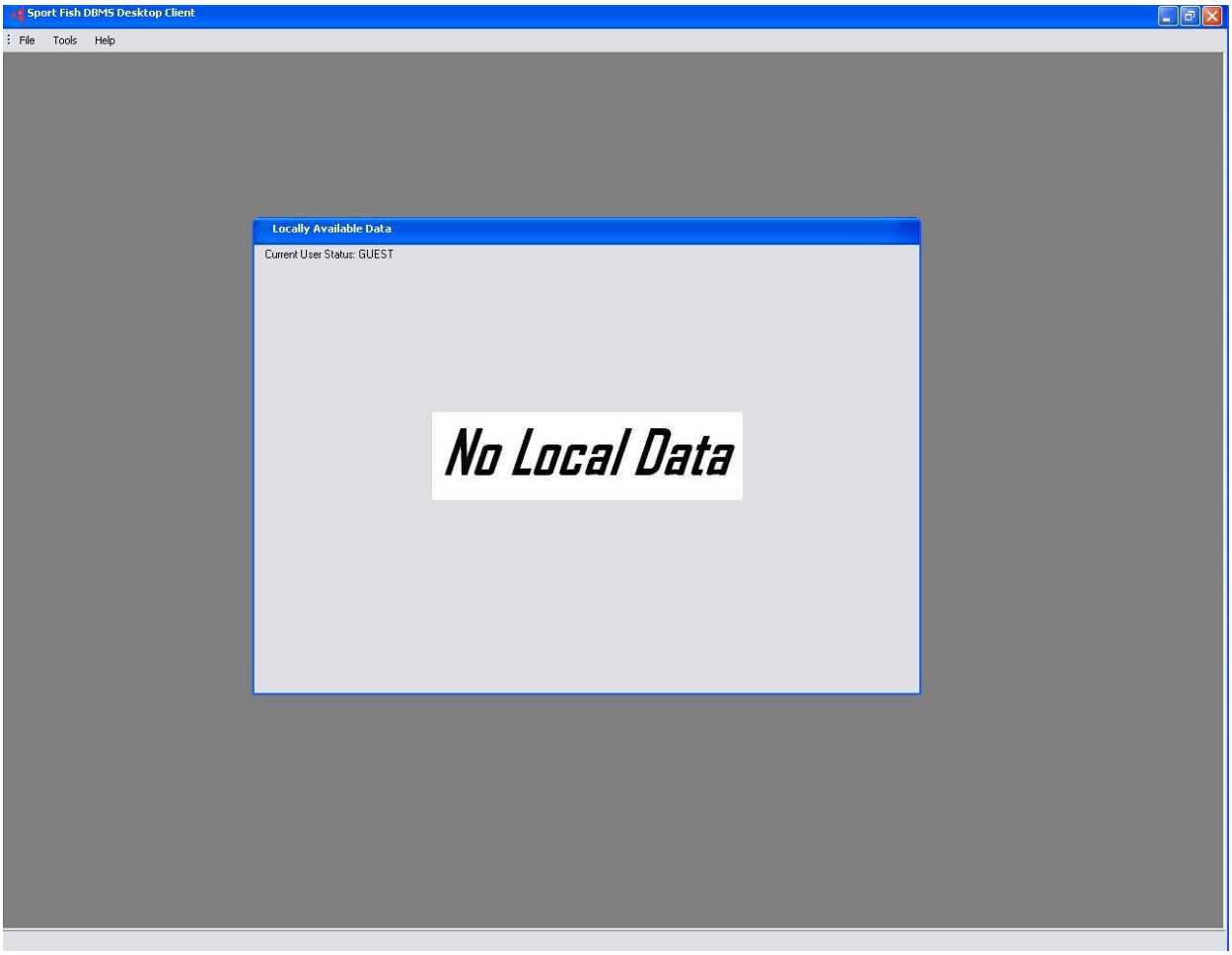
Transect______ → **water**

quad no.	***(TOP) +5.0ft***										
Distance											
Elevation/ Flood out time	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*	*field* *calc*

APPENDIX C: DATABASE ENTRY INSTRUCTIONS

Appendix C1.–Database entry instructions.

Clam database initial entry screen:



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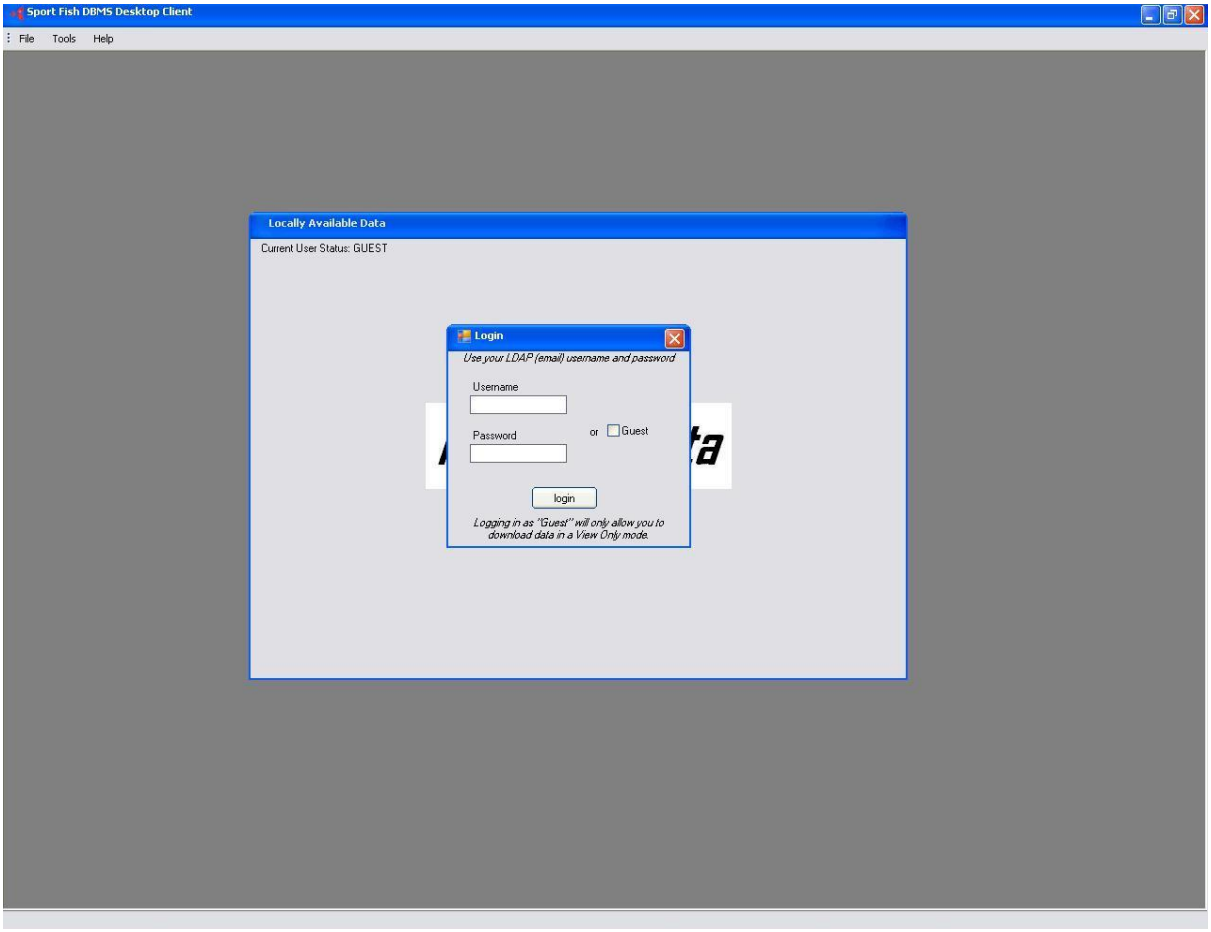
To log into the database, go to “File Login.” Use your LDAP username and password and press the “login” button.



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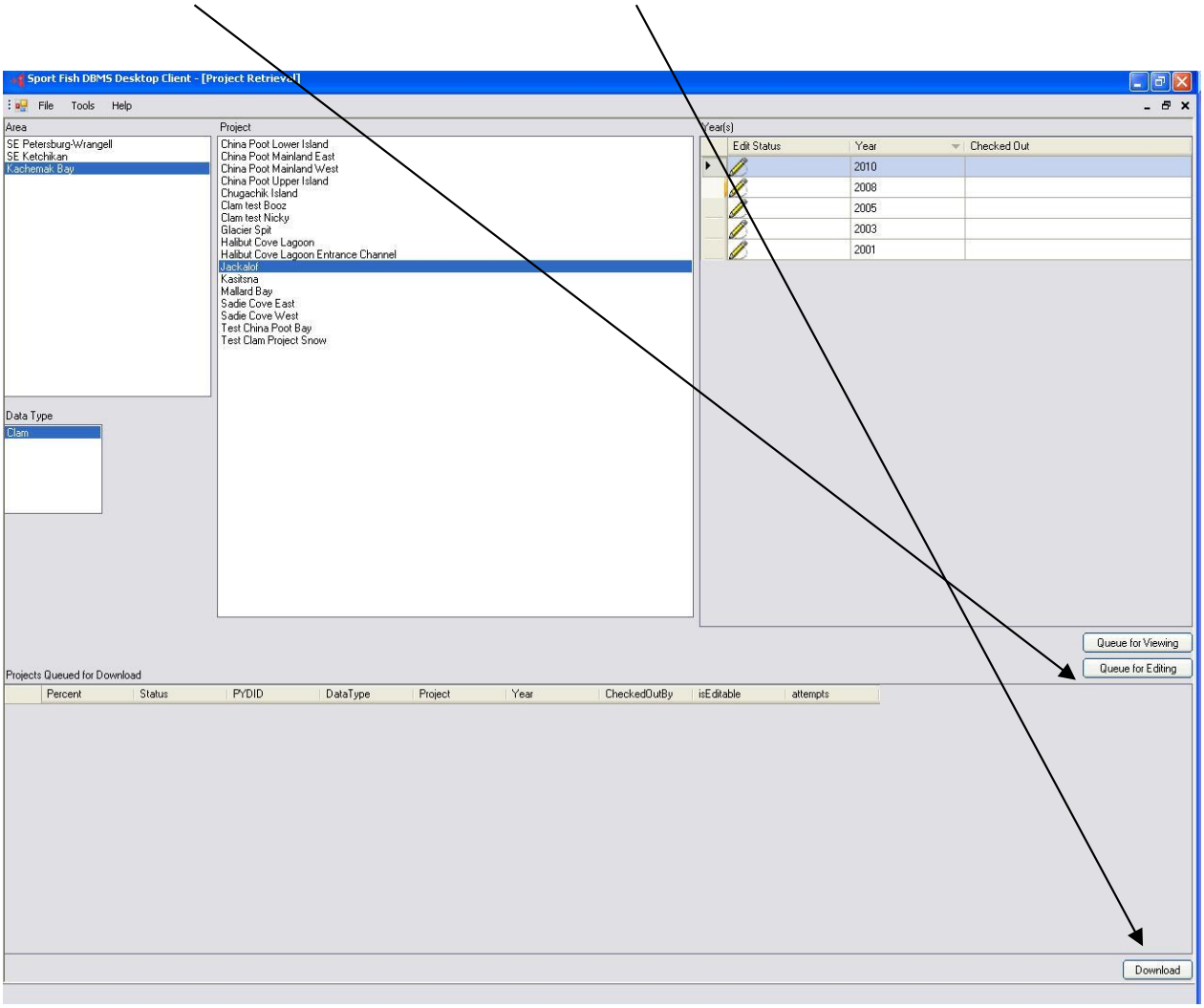
To download a dataset, go to “Tools>Data>Download Data.” Then, for example, select **Area** “Kachemak Bay,” **Data Type** “Clam,” **Project** “Jackolof,” **Year** “2010.” Then press the “Queue for Editing” button and then press the “Download” button.



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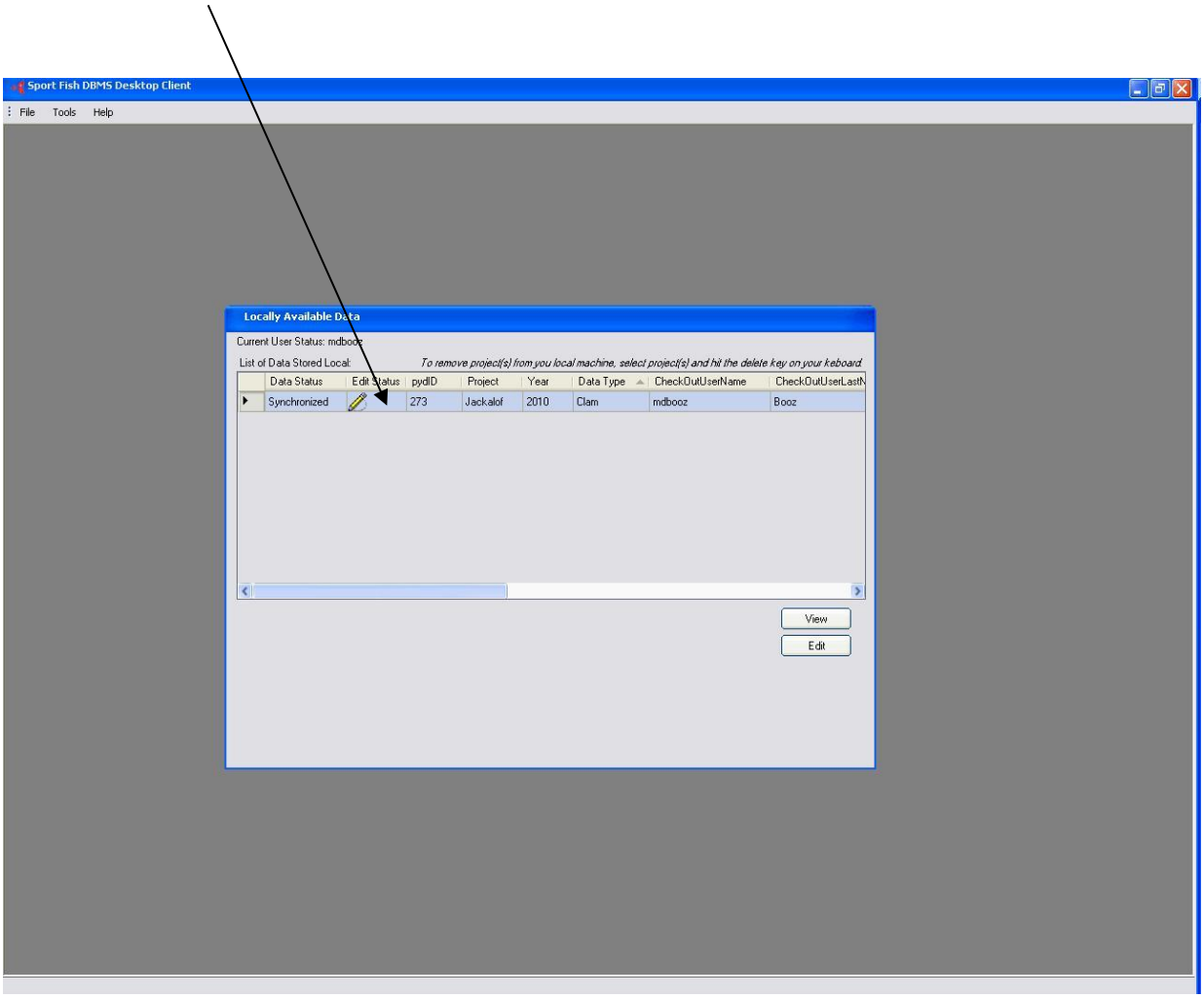
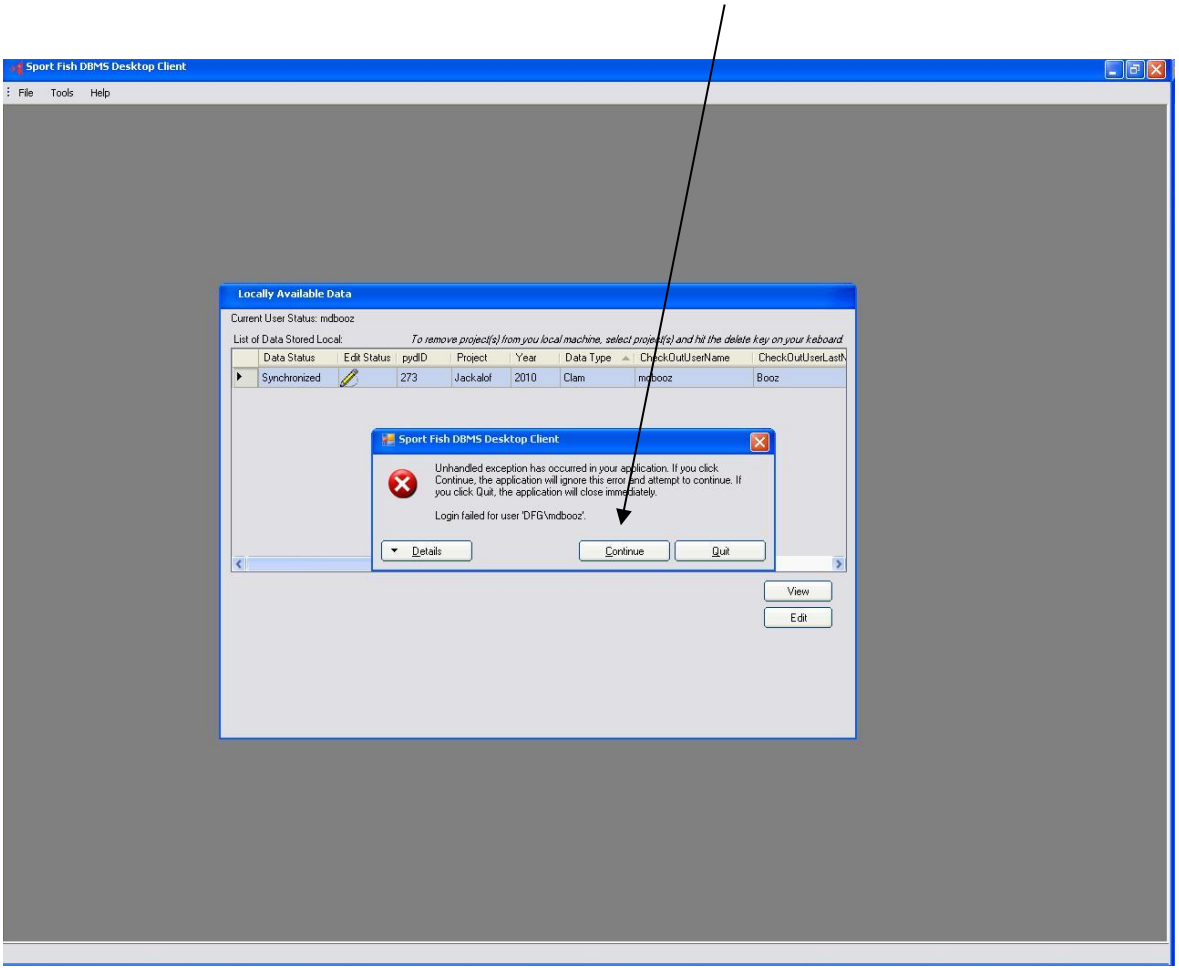
After the project is successfully downloaded, press the “OK” button. Then make sure the correct dataset is highlighted and press the “Edit” button.



For the first time data are entered into the project, there will be a warning “No data for this project.” Press the “OK” button.

-continued-

You may also get this warning (below). Press the “Continue” button.



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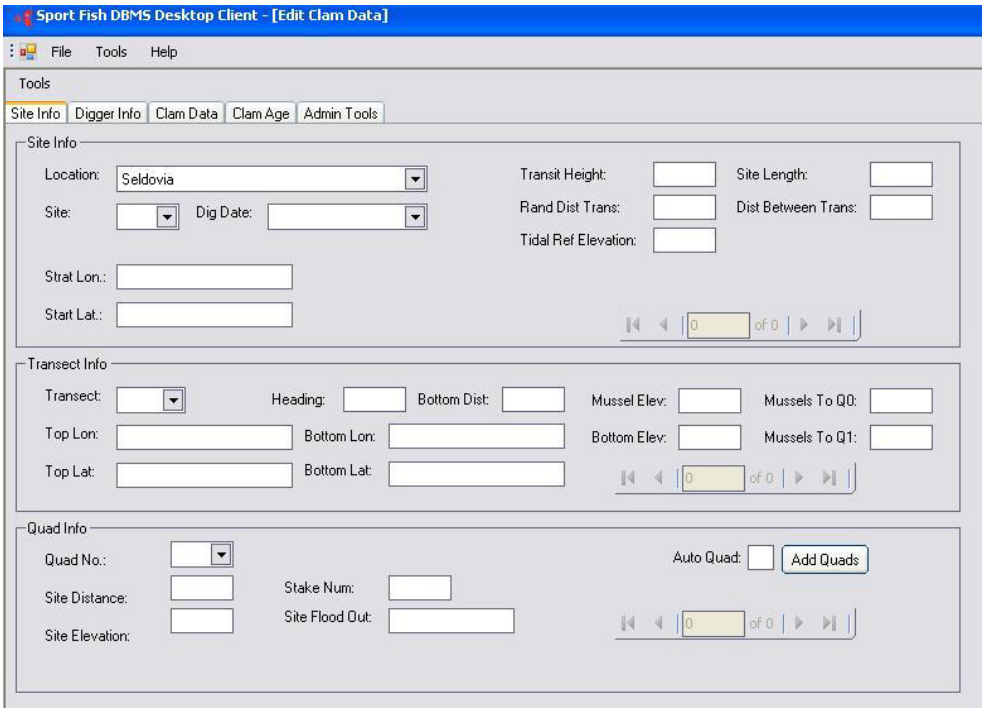
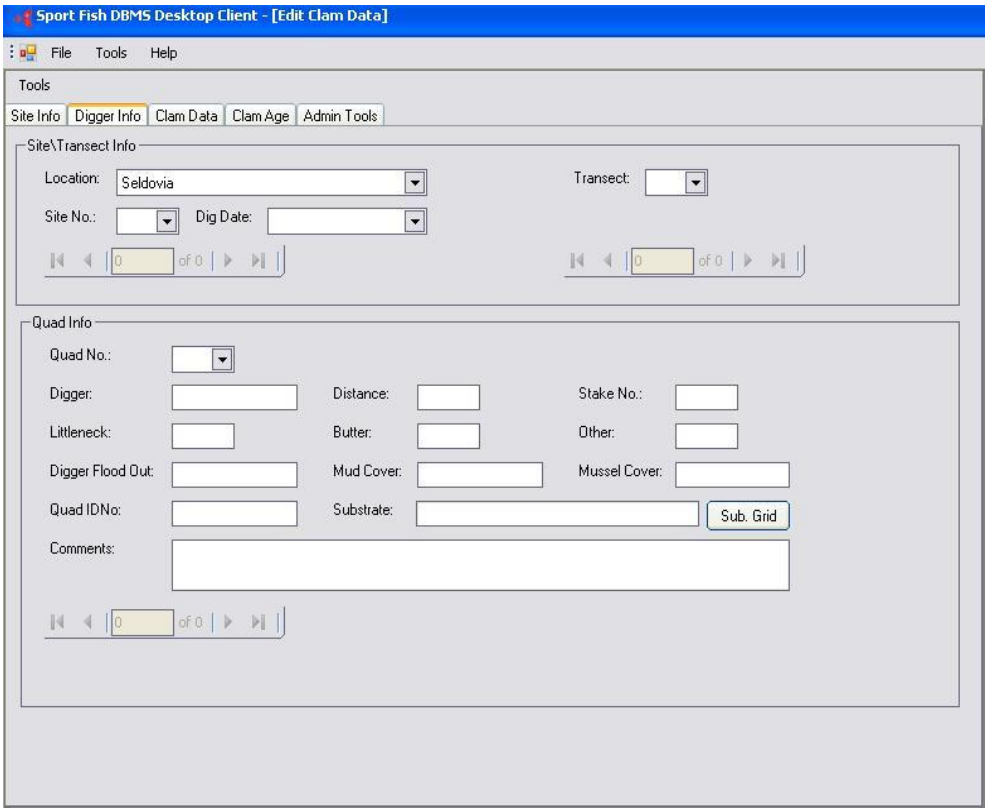
The data are entered within different tabs. This is the site info tab:



This is the digger info tab:



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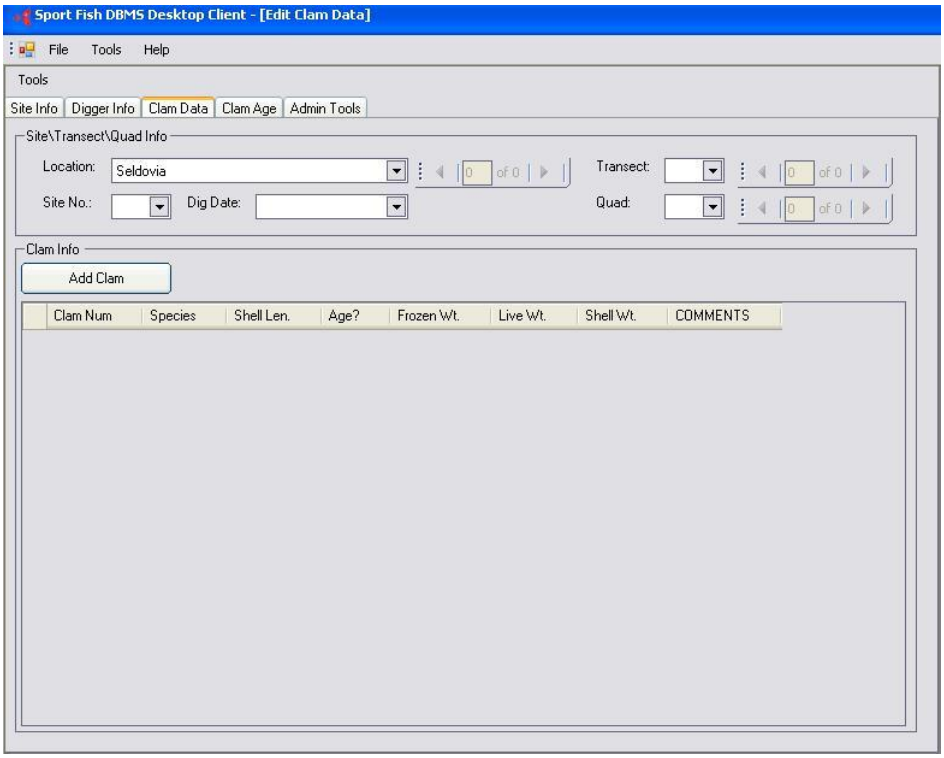
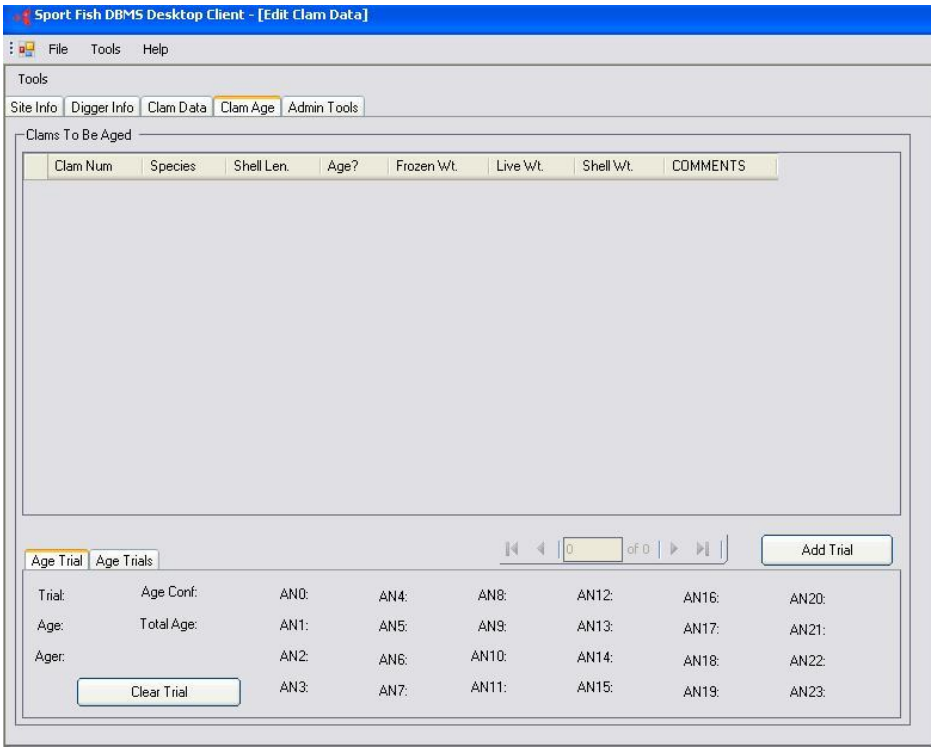
This is the clam data tab. To add clam data, press the “add clam” button.



This is the clam age tab.



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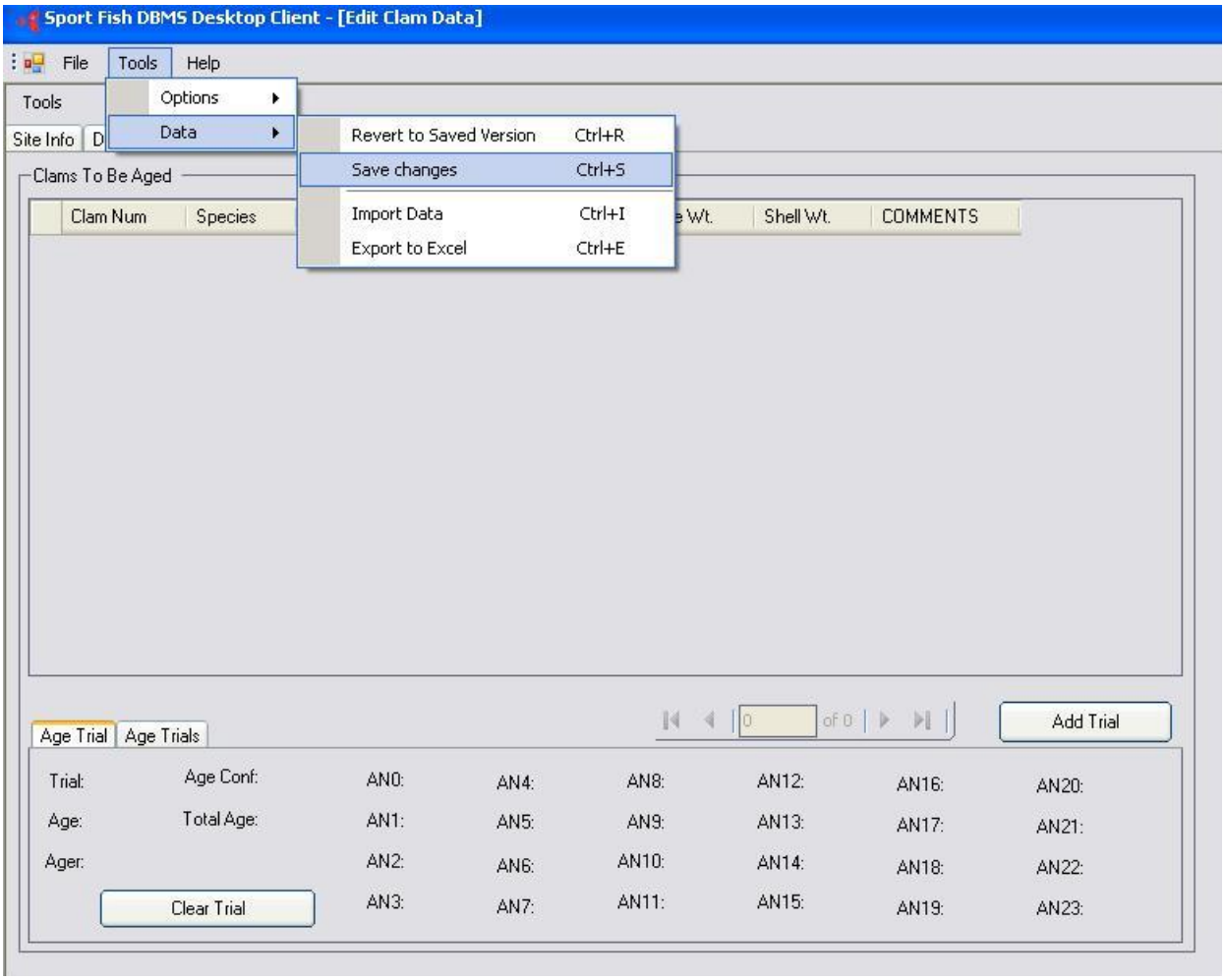
After you are finished entering data, go to “Tools>Data>Save changes.” You may get a warning that says, “It does not appear that any edits have been made.” Ignore and press the “Yes” button then close the window by pressing the “X” button in the upper right corner.



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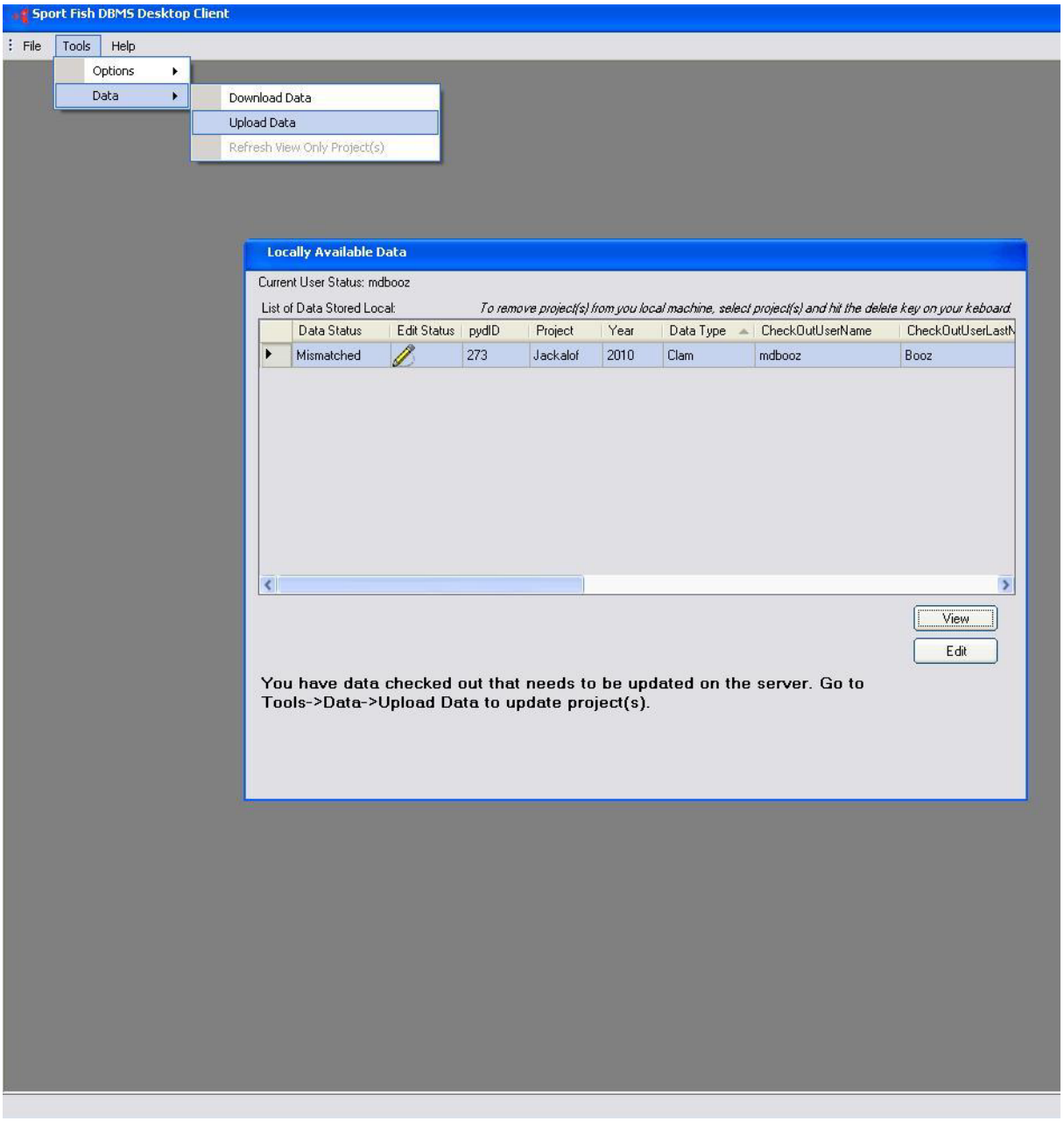
Then you will need to upload the data. Go to “Tools>Data>Upload Data.” Notice that the project status is mismatched. You will not be able to upload any projects until the data status is synchronized.



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Check the data stored box and press the “Sync” button. After the data have been successfully uploaded, press the “OK” button.